Kaon XS Analysis

A work in progress

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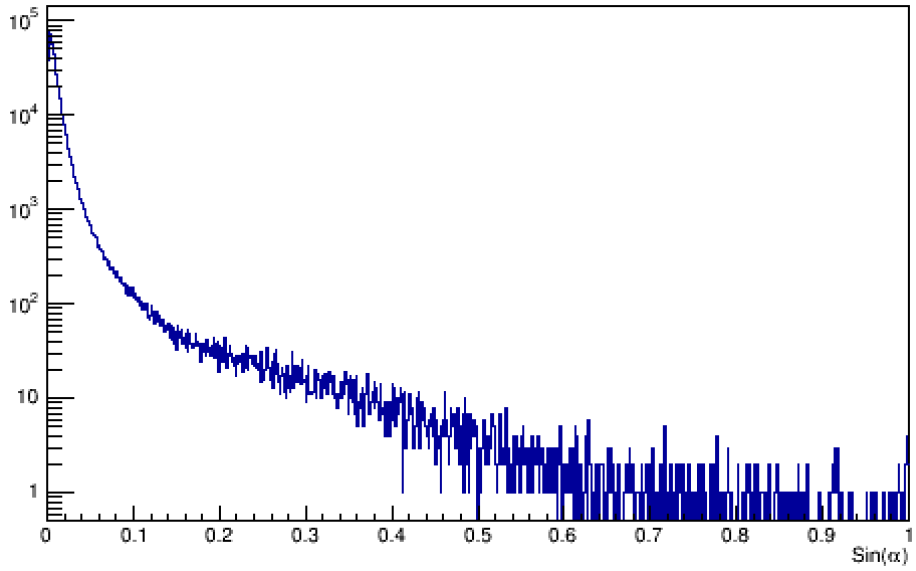
MC Reco XS

1) LArG4 Scattering
2) Preliminary plots

MC Reco XS

LArG4 Scattering

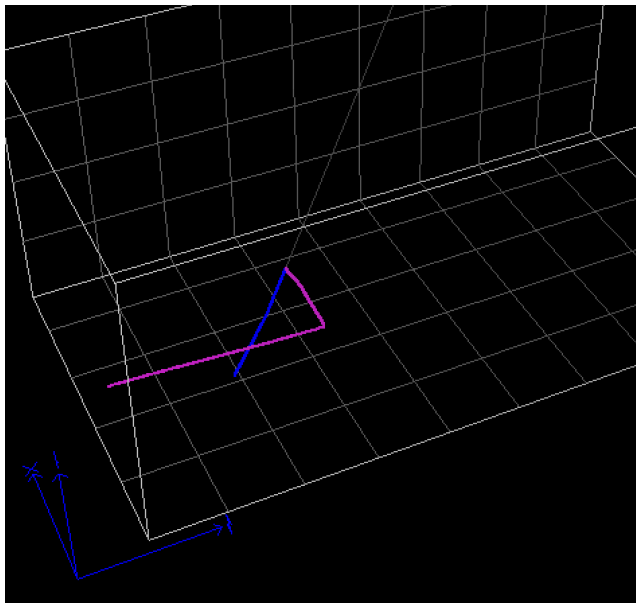


Plot represents the Sin(α) between two adjacent trajectory points in primary truth track of entering kaons.

Frequent untagged scatters >10° (.17) and several >45°(.71)

LArG4 does not label all scatters.

To compare Data and MCReco XS, need to understand and tag unlabeled scatters



85° scatter LArG4 calls a Decay.

MC Reco XS

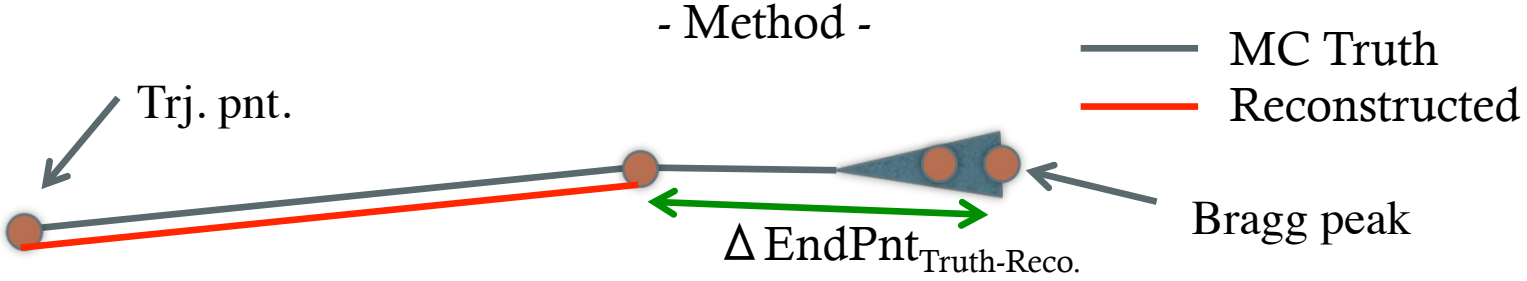
LArG4 Scattering

Due to LArG4s bad scatter tagging, need to develop a way in MC Reco to catch unlabeled scatters to correctly calculate a cross section.

Approach is based purely on Reconstructed information.

This is to test MC reconstruction against data, not to measure inefficiencies in the detector or in the reconstruction techniques.

- Method -



1) Determine correct direction of reconstructed track by matching early z-points of the reco. track with the first points of the truth track that are in the TPC.
2) Measure the distance between reconstructed and truth track endpoints.
3) Tag events as scatter if this distance > 2.0 cm

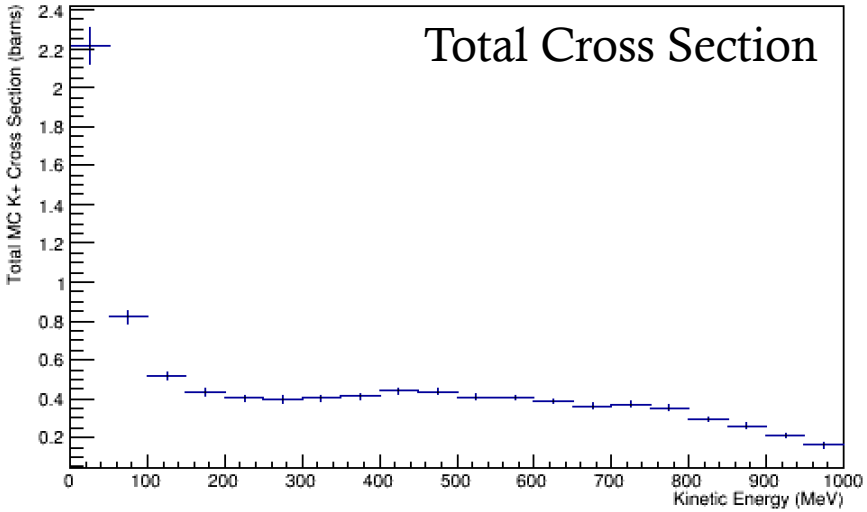
MC Reco XS

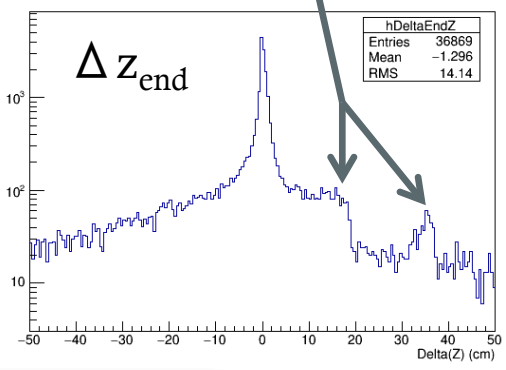
Preliminary Plots

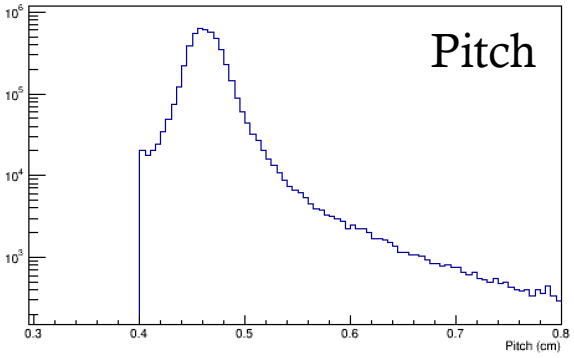
The first bin is still an issue, just as it was in the Pion analysis.

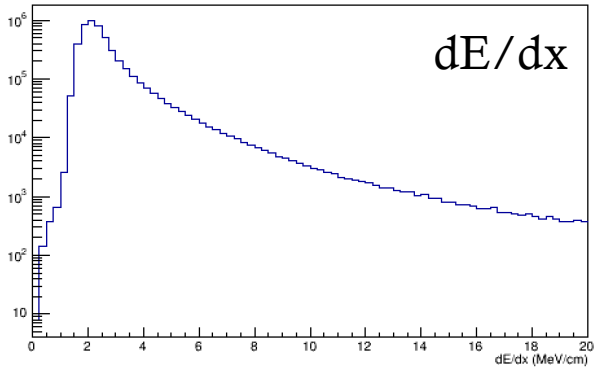
Need to study the possibility to do a cross section measurement at such low energies.

Structures greater than zero may represent reconstructed scatters that LArG4 does not label.









K+ Data XS

1) Current Run II statistics and issues
2) PIDA for Proton and Decay Tagging
3) Comparison against MC
4) Final Result

K+ Data XS

Run II Statistics and Issues

~ 70 % of Run II, 64 Gev, Pos. B-Field Runs

Cut	Events
Single WCTrack & TOF	433563
Mass Cut	9396
Aerogel Cut *BROKEN*	9396
Tighter Mass Cut	9134
1 WC-TPC Track Match	1396
Track Z Spacepoint < 2.0 cm	1296
< 10 Tracks in first 14 cm	1286
One WC-TPC Match	1177
Alpha < 10˚	1017

Aerogel cut is not present due to an issue in slicing that will be fixed very soon.

Tighter mass cut to make up for the missing aerogel information.

Heavy reduction. MC says ~50% of kaons do not reach the TPC and the remaining reduction is similar to that seen in pion analysis.

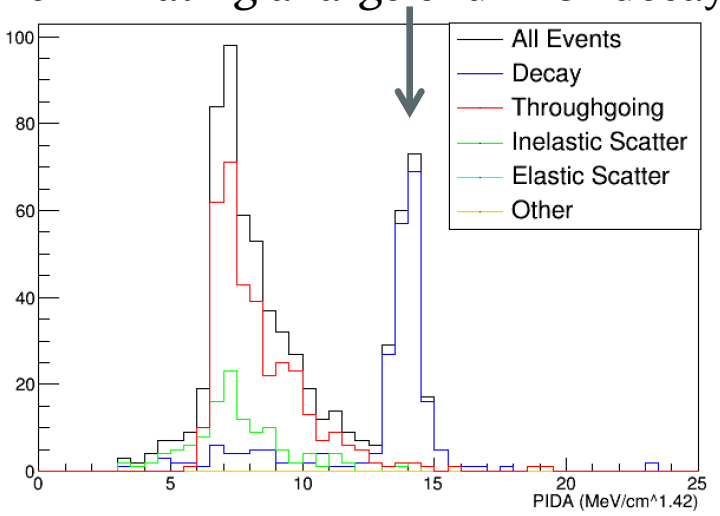
Issue of several WC-TPC matching algorithms in the analysis. Elena is developing a single alg. in LArIATSoft to be run only once.

K+ Data XS

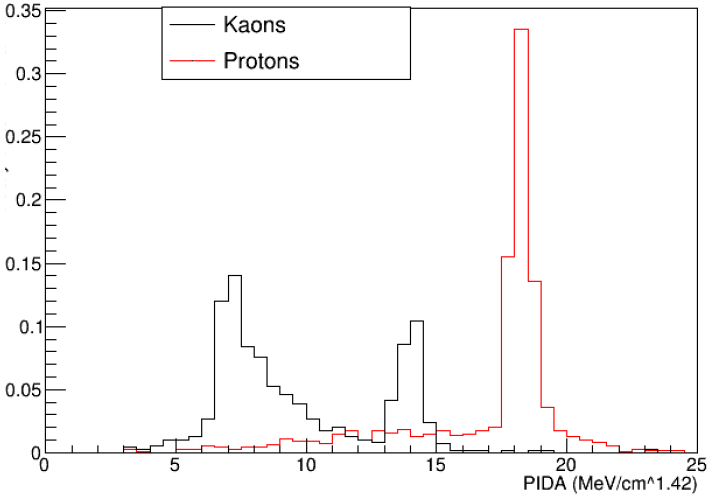
PIDA for Protons and Decay Tagging

PIDA is a PID module developed to detect stopping particles.
Please see arXiv:1306.1712 or LArTPC-doc-1883 for more information.

Potential to tag stopping K+, eliminating a large chunk of decays



Potential to remove Proton contamination because most protons stop in LAr.



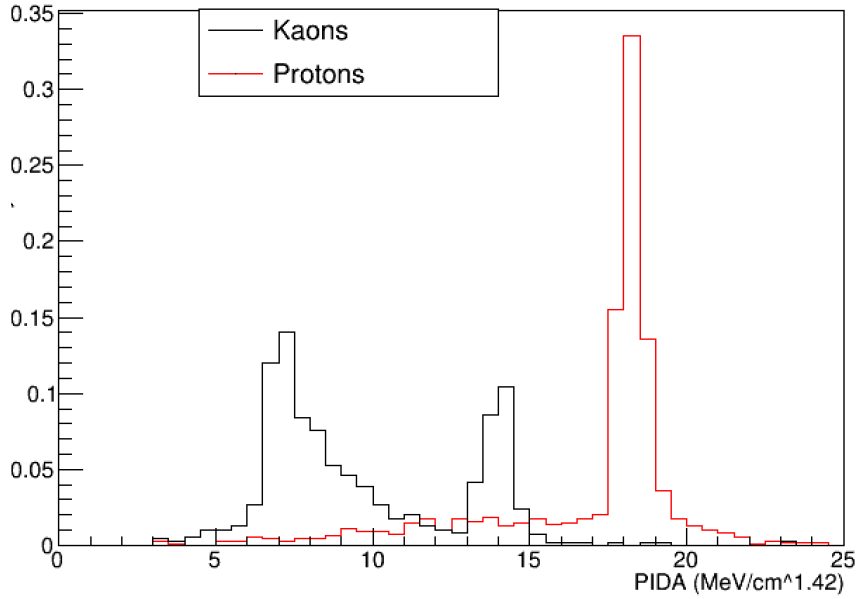
Note: K+ vs. Proton plot is normalized to show shape. This method can not be used to measure contamination without first knowing beam composition. Until that is understood, comparison is best done through normalization.

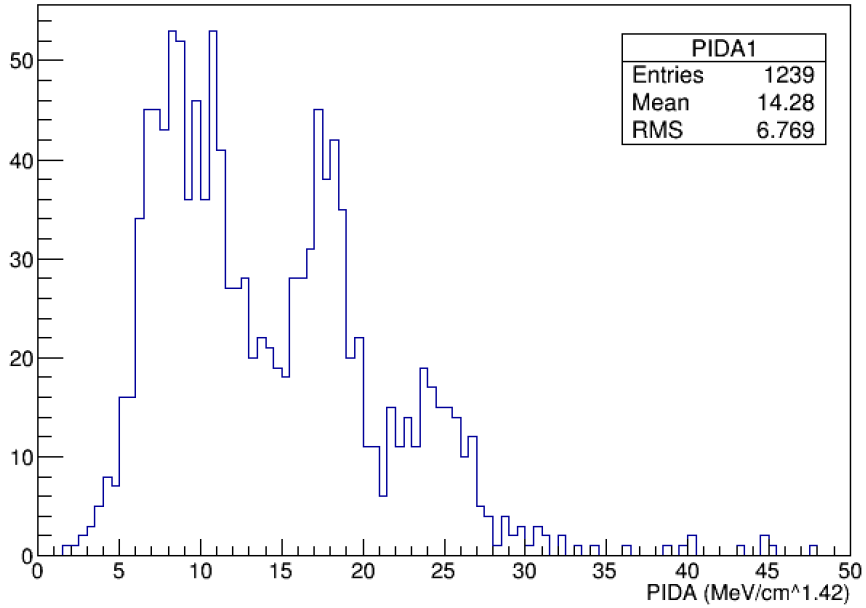
K+ Data XS

PIDA for Protons and Decay Tagging

Run II Data looks surprisingly similar to the MC.

Note: Normalized

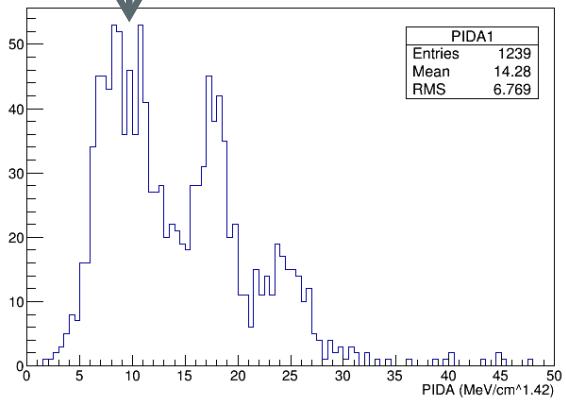




A scaling factor is present due to calorimetry tuning.
Relative distance between peaks are suspiciously similar.
And when you go and look into the event display ….

K+ Data XS

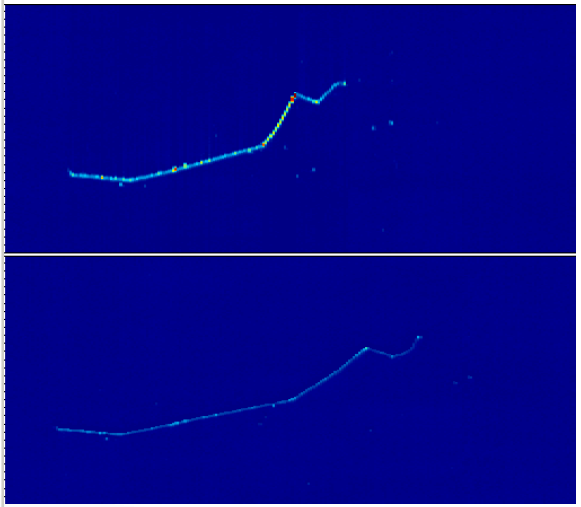
PIDA for Protons and Decay Tagging



The First Peak

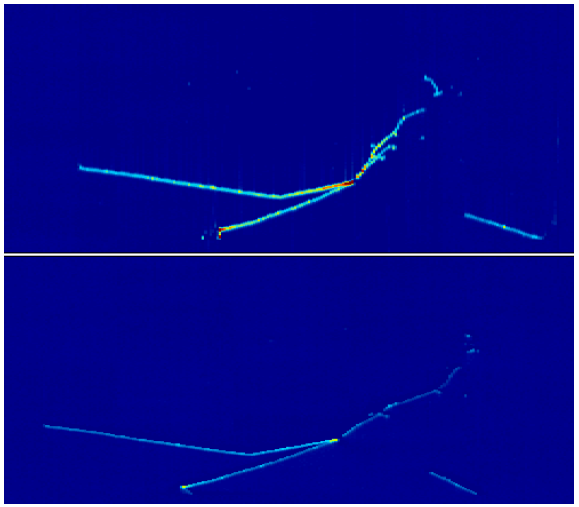
First peak represents tracks that did not stop, they must have interacted or gone entirely through the TPC

PIDA: 7.4



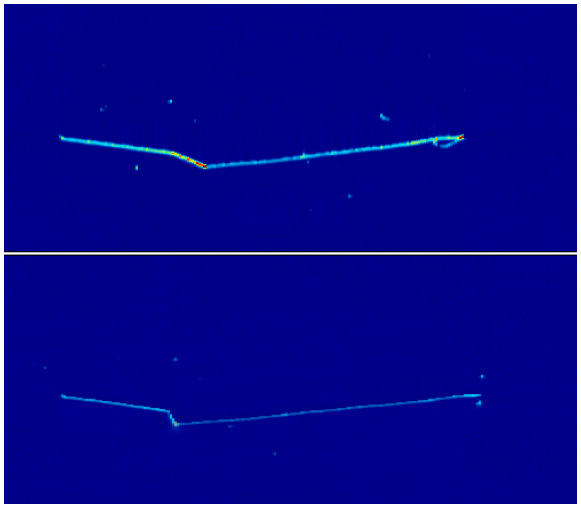
Rn 8123 Ev. 1458

PIDA: 11.5



Rn 8289 Ev. 14878

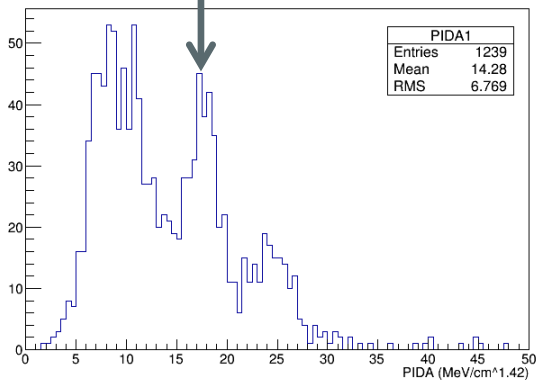
PIDA: 12.7



Rn 8315 Ev. 56

K+ Data XS

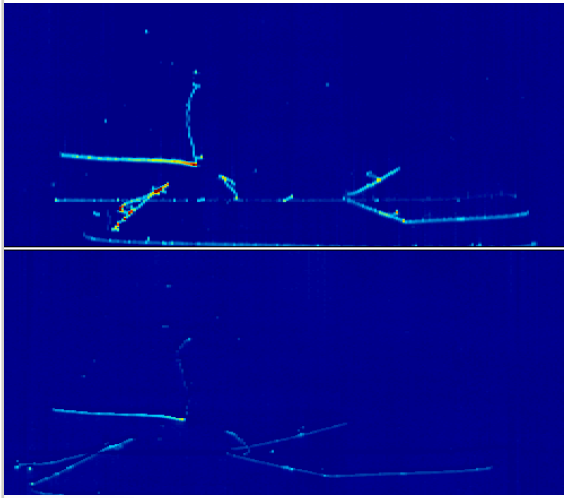
PIDA for Protons and Decay Tagging



The Second Peak

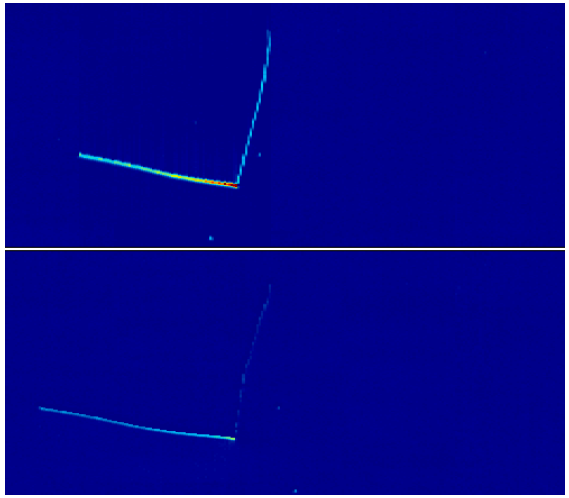
These are kaons that stopped in the TPC, depositing all of their energy on the way and fitting perfectly to the parameterized Bethe-Bloch equation.

PIDA: 16.9



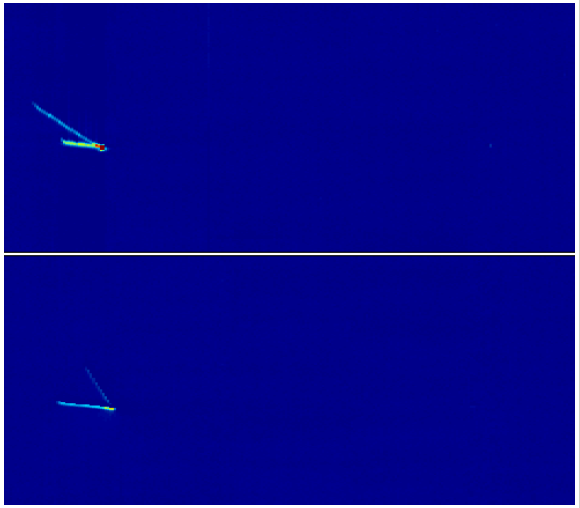
Rn 8284 Ev. 1238

PIDA: 16.2



Rn 8286 Ev. 7055

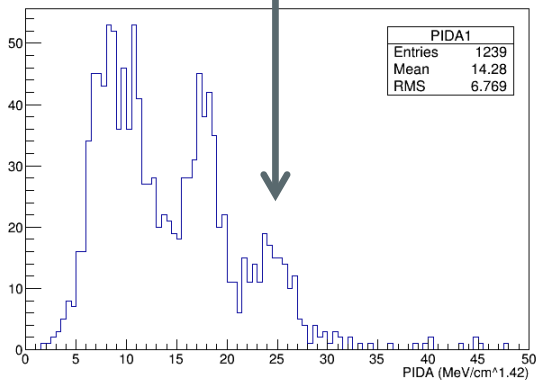
PIDA: 16.2



Rn 8286 Ev. 7355

K+ Data XS

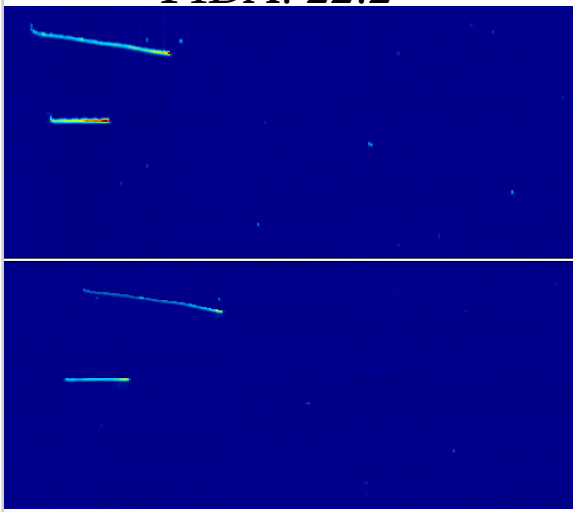
PIDA for Protons and Decay Tagging



The Third Peak

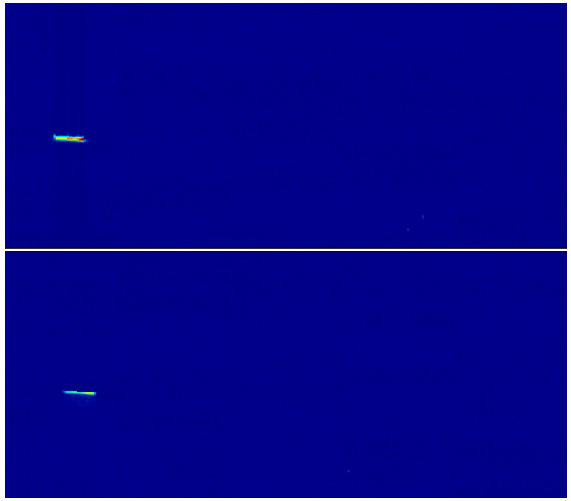
These values are unlikely for kaons and represent proton contamination, protons that enter and stop inside the TPC

PIDA: 22.2



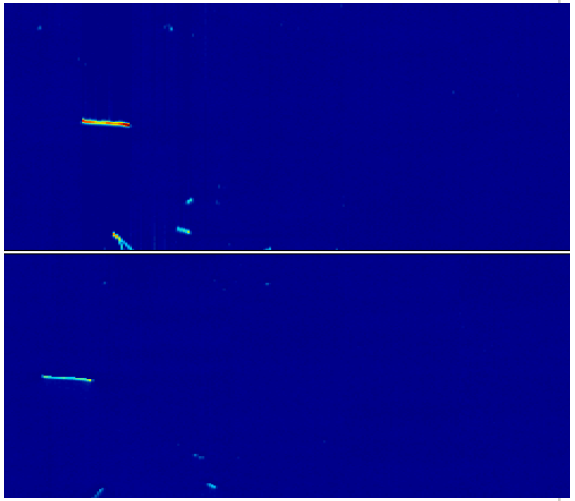
Rn 8281 Ev. 414

PIDA: 23.8



Rn 8279 Ev. 914

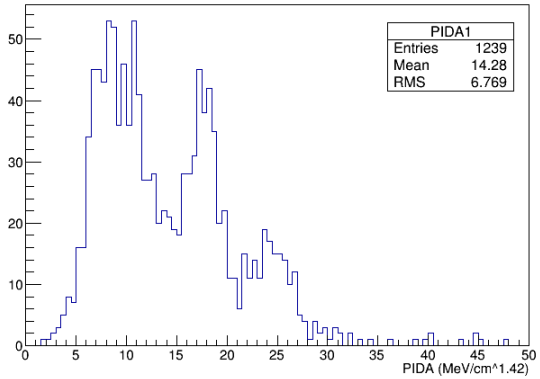
PIDA: 25.0



Rn 8286 Ev. 9210

K+ Data XS

PIDA for Protons and Decay Tagging

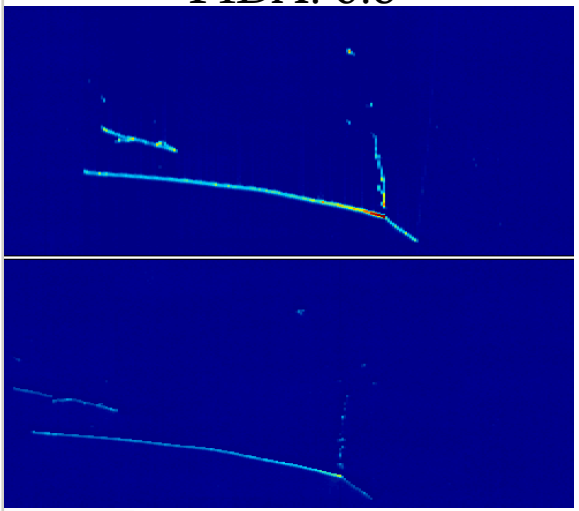


Tag Failing

Most failed PIDA tagging comes from a bad WC-TPC match or from PIDA values in between peaks.

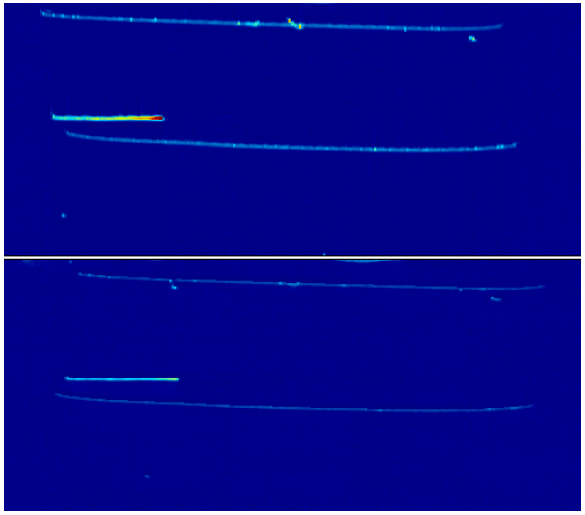
May be cut down by tightening TPC cuts and improving WC-TPC matching.

PIDA: 6.8



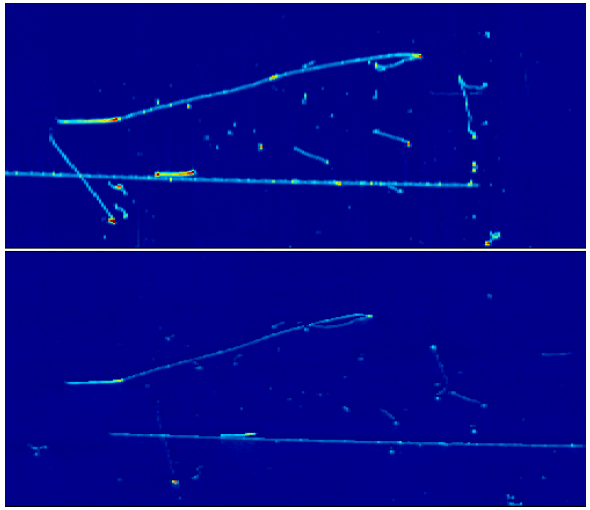
Rn 8279 Ev. 1272

PIDA: 4.7



Rn 8287 Ev. 5052

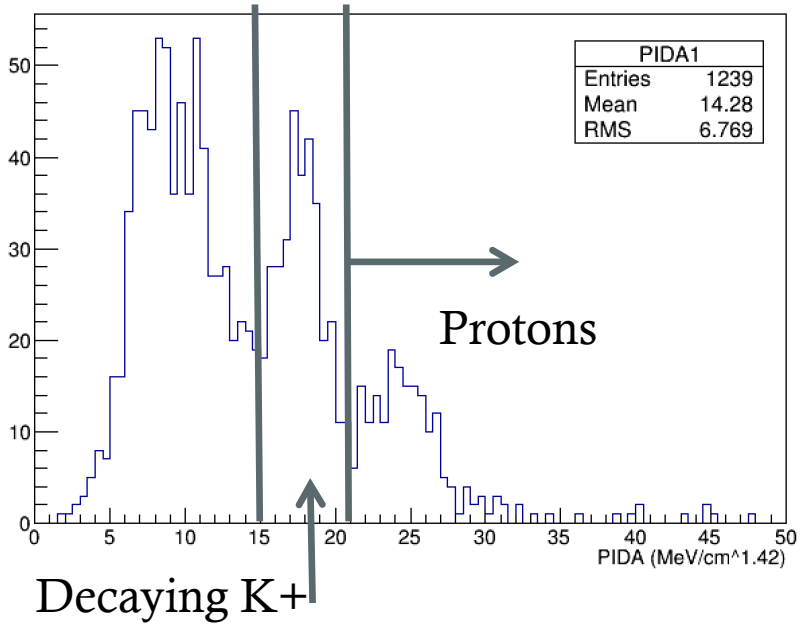
PIDA: 7.5



Rn 8298 Ev. 4416

K+ Data XS

PIDA for Protons and Decay Tagging



To remove Proton contamination, introduce a new cut to the current K+ selection scheme:
PIDA < 21.0

Cut	Events
All Previous Cuts	1017
PIDA < 21.0	872

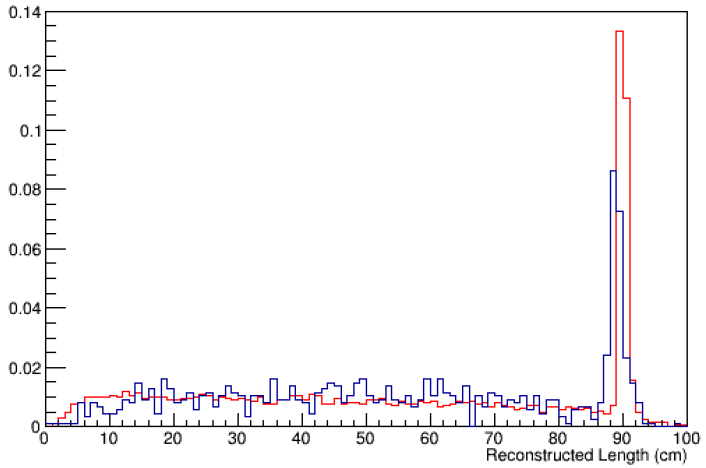
This cut for protons is analogous to the aerogel cut done to remove Pi/Mu

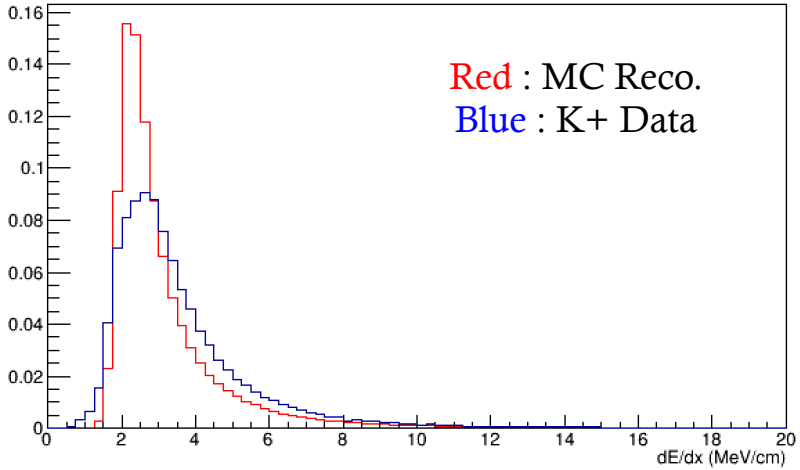
To remove K+ decays from the interactions bin, tag events as Decays if PIDA > 15.0.

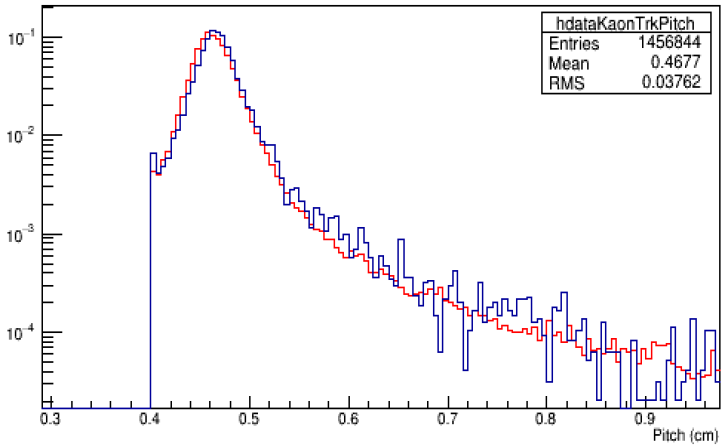
Obviously, much more work will need to be done to tune this Decay tagging function, but, for the preliminary cross section study, this is the method currently implemented.

K+ Data XS

Comparison against MC





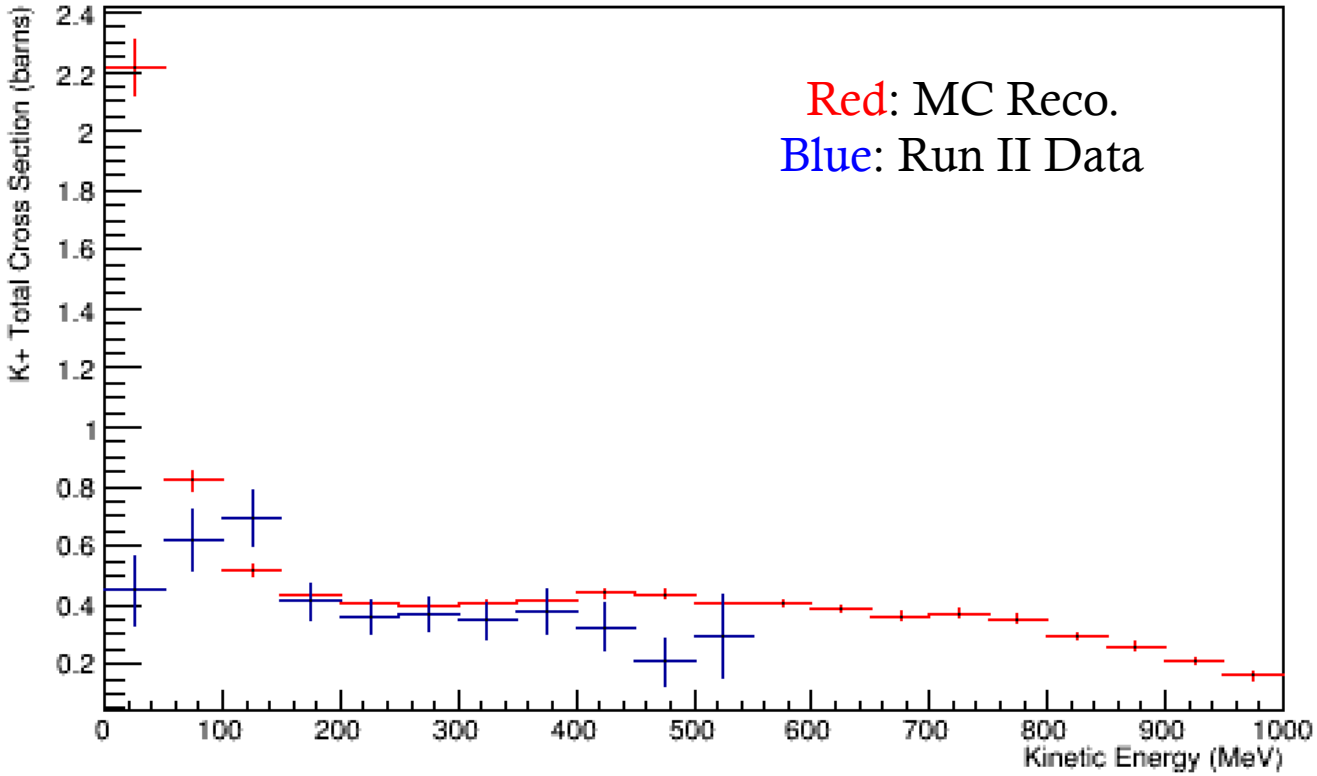


dE/dx MPV of ~3. Bad landau fit, need to use a convoluted landua-gaus fit.

Comparison of Recolengths may reveal Pi/Mu presence (too many through going) or proton presence (too many short tracks). No compelling evidence of either.

K+ Data XS

Preliminary Result



MC Truth XS

LArIATSoft limitations and Future Plan

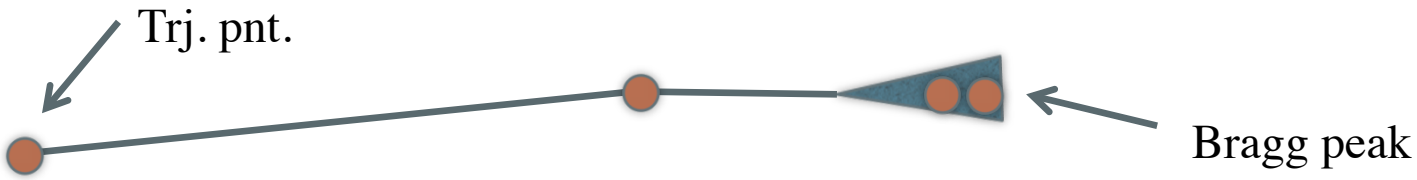
K+ Truth XS

LArIATSoft Limitations

Too much information on kinetic energy is lost in the conversion between LArIATSoft and Geant4 to create a K+ Truth XS inside of LArIATSoft

Truth track is as a series of trajectory points, each with a location and momentum.

No information on energy of track in between the trajectory points, this information is not saved between LArIATSoft and Geant4.



For our XS analysis, need to create thin slabs out of the trajectory points, meaning points in between trj. pnts. need to have a known KE.

Done by applying a uniform change of KE for each point in between two trajectory points. This approach, and I believe any other approach, would not work because it does not accurately represent dE/dx.

K+ Truth XS

LArIATSoft Limitations

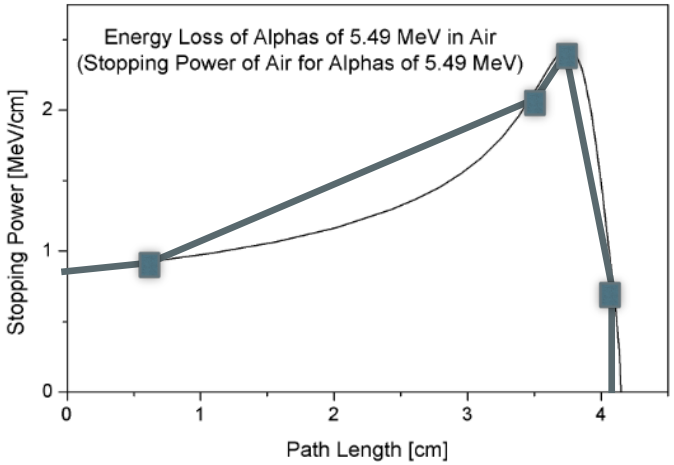
This plot is true dE/dx vs. path length compared against a recreation of the dEdx method described on the previous slide.

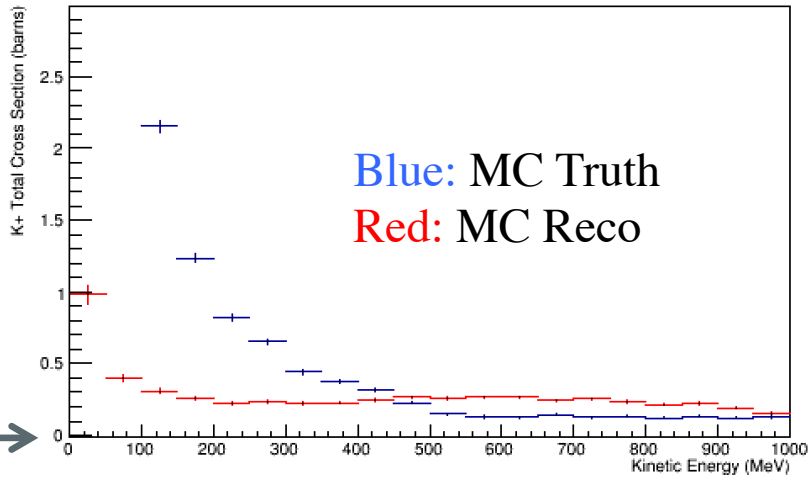
The blue dots represent the trajectory points.

This method makes most points near the end of a track (potentially all of the track) lower KE than truth, shifting the incident histogram towards the lower energy range.

Does Not effect interaction histogram as this energy is received from the trj. pnts.

Notice the hiding bin here at almost zero.





K+ Truth XS

Future Plan

This issue makes it necessary to create the Truth XS directly in Geant4.

Somewhat magically, Hans Wenzel has created a Geant4 study to do just that.

https://github.com/hanswenzel/G4HadStudies

The next step for the Truth XS would be to investigate
and update this code for our analysis.

In regards to the MC Reco study, this can still be done completely in
LArIATSoft because the dE/dx information is Not lost.

Backup

PIDA Recap

PID module developed for ArgoNueT, living in LArSoft

Uses expected power-law dependence of dE/dx for **Stopping particles** as described by the Bethe-Bloch equation. Can be approximated using:

$$(dE/dx)_{hyp} = A\,R^{b}$$

Where R is residual range and A and b are parameterization variables.

Setting b = -0.42, the module finds A by taking the average of all spacepoints in the track using:

$$A_i = (dE/dx)_{calo,i} R_i^{0.42}$$

This number A is unique for a stopped particle:

Error from fixed b is negligible compared to ionization fluctuations.

Particle	A MeV/cm^{1-b}	b
pion	8	-0.37
kaon	14	-0.41
proton	17	-0.42
deuteron	25	-0.43